Synthesis and Characterization of gas sensing Metal oxides by Sol-Gel method

Synopsis in candidature for the degree of

Doctor of Philosophy in Physics

Submitted

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1. Introduction

Researchers are trying to fabricate suitable materials that could be employed as better gas sensors with fast response, long-term stability, high sensitivity, and greater selectivity [1]. In recent years, numerous gases and volatile organic compounds (VOCs) have been utilized in large areas of industrial production and research applications as one of the reaction agents [2]. There is an important point to be concerned to control and monitor these harmful species, considering a huge risk of damage to assets and human beings if a leak occurs. There are certain gases which can be toxic for humans, and can cause big explosions. Accordingly there is a need of gas sensors with the intention of continuous and effective detection of these gases to evade predominantly the above said dangers. Air pollution is an important environmental issue due to intensive industrial manufacturing processes, car exhaust, biomass burning, combustion of fossil fuels, and microbiological emission from soil. The main air pollutants such as NOx, SH_2, NH_3, and some volatile organic compounds (VOC) contribute to a greenhouse effect and can cause respiratory diseases such as bronchitis, emphysema, as well as heart problems [3]. Therefore, the demand for new sensors, which are suitable for the determination of gases and/or VOCs, is constantly increasing. In the development of gas-and/or VOC-sensors, metal oxides such as TiO_2, SnO_2, WO_3, and ZnO are widely used as sensing components of analytical signal transduction systems, because of their high sensitivity and stability [4,5].

Among many other oxides, tungsten (VI) oxide (WO_3) is a very attractive material due to its relative chemical stability, robustness, inherent electrical conductivity, and good sensitivity towards various gaseous materials including many VOCs [6-8]. Various WO_3-based structures are also used in lithium-ion batteries [9] and solar energy conversion systems [10-13]. The gas- and/or VOC-sensing and photoelectrochemical properties of WO_3 are highly dependent on the deposition method and conditions of sensitive layer formation. Different methods, such as reactive radiofrequency (RF) sputtering [13], hydrothermal synthesis , spray pyrolysis , electrodeposition , and sol-gel based surface modifications are applied for the formation of WO_3 films. Sol-gel technique for the formation of WO_3 layers is among the most attractive ones, because this technique does not require any sophisticated and expensive equipment, the control of surface modification process is easy, and different variations of sol-gel based techniques can be applied for gas-sensing layer deposition on various substrates . Various WO_3-based structures exhibit excellent sensing properties towards various oxidizing and reducing gases and/or VOCs and, therefore, different WO_3-based structures can be used for particular safety-related applications, for example, the

detection of indoor air pollutants, monitoring the toxic, flammable or explosive gases, and/or VOC in different environments. Some other sensing applications are related to medical diagnostics, e.g., the evaluation of exhaled acetone , etc. It is known that the performance of gas sensors is highly dependent on the morphology, crystallite dimensions, and porosity of WO_3-based sensing layers. From this point of view, nanostructured materials are very attractive due to their large porous surface, which is important for the sensitivity of sensing layer.

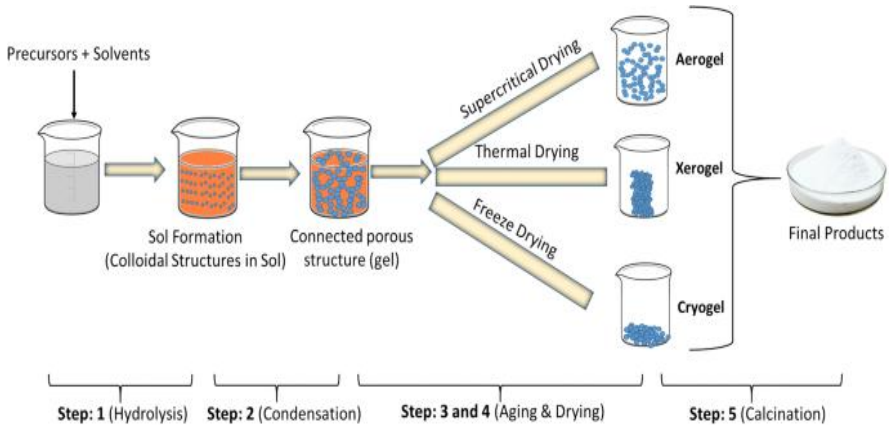
An ideal gas sensor should posses the following sensing properties :

- High Sensitivity to certain gases
- Reversibility
- Faster response time and good recovery time.
- High Selectivity
- Long term Stability
- Simple principle of operation
- Easy to handle.
- Simple fabrication techniques.
- Temperature insensitive.

Methodology:

Sol-gel

The sol–gel process is a wet chemical technique also known as chemical solutiondepo sition, and involves several steps, in the following chronological order: hydrolysis and poly-condensation, gelation, aging, drying, densification, and crystallization. the sol–gel process is a method for producing solid materials from small molecules. The process involves conversion of monomers into a colloidal solution (sol) that acts as the precursor for an integrated network (or gel) of either discrete particles or network polymers.



Characterization

Different measurement techniques to characterize the structural, magnetic, dielectric and electrical properties of the specimens can be employed.

[1] X-ray powder diffraction (XRD) is a rapid analytical technique primarily used for phase identification of a crystalline material and can provide information on unit cell dimensions. The analyzed material is finely ground, homogenized, and average bulk composition is determined.

[2] A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons.

[3] The morphology, particle size and shape are revealed through field emission scanning microscopy (FE-SEM).Field emission scanning electron microscopy (FESEM) provides topographical and elemental information at magnifications of 10x to 300,000x, with virtually unlimited depth of field. Compared with convention scanning electron microscopy.

[4] HR-TEM is a powerful tool to study properties of materials on the atomic scale, such as semiconductors, metals, nanoparticles.

[5] FTIR provide information on the basis of chemical composition and physical state of the whole sample

So all these above mentioned are the characterization techniques are very useful for knowing the material structure and properties of the material. .

Proposed work plan

Literature survey

Selection of materials

Synthesis of metal-oxide

Characterization

Collecting data and optimizing

Writing paper

Publishing in reputed journals

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